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EVOLUTIONARY RESILIENCE AND COMPLEX LAGOON SYSTEMS

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EDITORS' NOTE

This paper represents 1 of 5 review articles generated from 2 research projects funded by the European Union's Seventh Framework Program, ARCH and LAGOONS. The projects aim to develop and apply participative methodologies in collaboration with key stakeholders, to manage the multiple problems affecting European lagoons and estuaries. The articles in this series provide strategies for the sustainable management of these vulnerable ecosystems, which are increasingly threatened by climate change, urbanization, and industrialization.

ABSTRACT

This paper applies an evolutionary resilience framework to complex socio-ecological systems in the coastal regions in Europe with a particular focus on lagoons. Despite their variations, lagoons share common challenges in achieving effective and sustainable ways of governing and managing economic, social and environmental uncertainties. Our aim is to demonstrate that building resilience involves planning not only for recovery from shocks, but also for cultivating preparedness, and seeking potential transformative opportunities which emerge from change. The framework consists of four dimensions namely, persistence, adaptability, transformability and preparedness. In order to illustrate how this four-dimensional framework can be applied to the specific context of lagoons, the paper draws on examples of good and poor practices from the ten lagoons studied as part of the ARCH Project.

KEYWORDS

Evolutionary resilience, Lagoons, Estuaries, Coastal management, Complex systems

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INTRODUCTION

At the interface of land and sea lie lagoons (estuaries and fjords) which represent dynamic and complex socio-ecological systems. Such systems are "organized assemblages of humans and non-human life forms" (Halliday and Glaser 2011, 2) made of bio-geo-physical and social systems (Gallopin 2003, 15) with the latter encompassing intricate economic, cultural, political and institutional interrelationships (Stokols *at al*. 2013). Lagoons are "made up of living and non-living components that interact with each other by way of complex exchanges of energy, nutrients and waste" (Turner *et al*. 2014, 19). They have developed in the course of natural processes (e.g. lithological, morphological, chemical, geological, biological, etc.) taking place in interaction with social and economic pressures. They are major sources of natural capitals such as: stocks of living organisms, soil, fossil fuels, minerals and biodiversity. They produce various types of critical ecosystem services such as food, medicine, fertilizers, nutrient and CO_2 absorption. They are also sources of inspiration, cultural heritage and recreational values that are important for overall human well-being and quality of life (Ressurreição *et al.* 2012).

Lagoons and estuaries are part of a vast network of coastal regions which are home to some 40% of the EU's population (based on residence within 50 km of the sea) and generators of some 40% of the EU's GDP (EEA 2013). For example, 75% of the volume of the EU's foreign trade is conducted by sea. However, the economic contributions of the EU coasts have come at a high environmental cost. Lagoons and estuaries are under increasing pressures from various economic activities as well as climate change and other impacts of emissions (such as rising sea level, temperature and ocean acidification). Activities such as shipping, resource extraction, power plants, renewable energy, agriculture, fishing and tourism are putting pressure on marine, coastal and lagoon areas, resulting in loss of habitat, pollution and accelerated coastal erosion and vulnerability to sea level rise and other climate change effects (EEA 2013). On the one hand, their relatively shallow water, proximity to the coast and rich natural resources make them particularly attractive to recreational, tourism and fishing activities. On the other hand, these activities make lagoons vulnerable to problems of pollution, eutrophification and sedimentation. The resilience of the lagoons and the regions around them depend on mutually beneficial relationships between their natural, human, social, moral and physical capital.

In this paper, we explore how a four-dimensional evolutionary resilience framework developed by Davoudi *et al.* (2013) can be applied to the specific context of lagoons which, despite variations, share common challenges in seeking effective and sustainable ways of governing and managing economic, social and environmental uncertainties. Our aim is to demonstrate that building resilience involves planning not only for recovery from shocks, but also for cultivating preparedness, and seeking potential transformative opportunities which emerge from change. We use examples of good and poor practices from the lagoons studied as part of the ARCH Project to illustrate the arguments made.

The aim of this paper is to give a greater clarity to evolutionary resilience theory with reference to coastal and lagoon management through a series of illustrative examples. It is intended to inform the management of estuary and lagoon areas that ARCH set out to establish by integrating the diverse disciplines that relate to coastal and marine zones; and linking these into an ongoing policy process, by means of stakeholder involvement. To achieve this, the ARCH methodology included desk-based studies of the socio-ecological state of the lagoons (Zaucha and Breedveld 2013) and deliberations with stakeholders in each lagoon through three participatory workshops, resulting in strategies (‘roadmaps’) towards sustainable lagoon management. The theory of resilience proposed in this paper, in looking beyond sustainability to consider the capacity of the lagoon and estuarial areas to recover from shocks and disturbances, is therefore best understood as running alongside, rather than framing, the processes and methods of the ARCH project.

UNDERSTANDING RESILIENCE

An extensive review of literature from a wide range of disciplines, undertaken by Davoudi (2012), has generated three broad conceptualizations of resilience: engineering, ecological and evolutionary resilience (the latter being sometimes known as 'socio-ecological' resilience). Engineering resilience refers to the ability of a system to return to an equilibrium or steady state following a disturbance. The emphasis is on return time, 'efficiency, constancy and predictability', all of which are deemed essential for optimal engineering design (Holling 1996, 33; Gunderson, 2000). Ecological resilience (Walker *et al.* 1969; Holling 1996) suggests that there are multiple equilibria and that "instabilities can flip a system into another […] stability domain" (Gunderson 2000, 426). While engineering resilience focuses on maintaining *efficiency* of function, ecological resilience focuses on maintaining existence of function (Holling 1996, 33), even though the function itself may have changed. Both engineering and ecological resilience have in common the idea of a stable equilibrium, 'be it a pre-existing [state] to which a resilient system bounces back (engineering) or a new [state] to which it bounces forth (ecological)' (Davoudi 2012, 301). More recently, what we call evolutionary approaches to resilience have challenged the idea that stability domains remain fixed over time (Scheffer 2009). The other name for evolutionary resilience, socio-ecological resilience, emphasises the way this embraces 'people and nature as interdependent systems' (Folke *et al.* 2010, 21). From this perspective, instead of viewing resilience as 'a return to normalcy' (Pendall *et al.* 2010, 76), it is conceived as the ability of complex social-ecological systems to change, adapt or transform in response to stresses and strains (Carpenter *et al.* 2005). In other words, it can embrace the kinds of evolutionary change which have characterized interwoven natural and human systems throughout history.

Holling has developed the understanding of evolutionary resilience in complex adaptive systems through the idea of ‘the adaptive cycle’ which consists of inter-nested subsystems at multiple scales and speeds going through cycles of growth, conservation, (creative) destruction and reorganization (Gunderson and Holling 2000). It is characterized by continual interactions between slow and fast systems and small and large ones. The longer, slower processes take place at a larger scale while at smaller scales, shorter and faster processes occur, together maintaining system resilience across the adaptive cycle. It can happen that they get stuck in the conservation phase, however, in which case they may become locked in and hence more vulnerable to future strains, which can disrupt the whole system. Also, importantly, phases do not necessarily have to follow one another in sequence – the cycle can skip a phase or two – so, for example, it is conceivable that reorganisation could follow conservation without the intervening phase of creative destruction.

RESILIENCE AND COMPLEX LAGOON SYSTEMS

The preceding discussions support Swanstrom’s (2008, 2) view that, “resilience is more than a metaphor but less than a theory. At best it is a conceptual framework” that helps us think about management of lagoons in new ways that are more dynamic and holistic. Evolutionary resilience broadens the description of resilience “beyond its meaning as a buffer for conserving what you have and recovering to what you were” (Folke *et al.* 2010, 25), to incorporate the dynamic interplay between persistence (the main component of engineering resilience), adaptability (drawn from ecological resilience) and transformability (the defining quality of evolutionary resilience) across multiple scales and timeframes in ecological systems (Davoudi 2012 drawing on: Holling and Gunderson 2002; Walker *et al.* 2004; and Folke *et al.* 2010; see also Miller *et al.* 2010).

However, lagoons are not just ecological systems, they are also social systems. The latter means that people can intervene and break the cycles through their technologies, ingenuities and foresights. People can anticipate change and hence encourage or discourage particular directions of change (Pendall *et al.* 2010, 78). Therefore, Davoudi *et al.* (2013) suggest that in applying the evolutionary resilience framework, an additional, fourth, component to the three mentioned above is needed, namely preparedness, to reflect the intentionality of human action and intervention (Figure 1) . Together, this four-dimensional framework suggests that, when confronted with slow or sudden disturbances, complex socio-ecological systems, such as lagoons, can become more or less resilient depending on the social learning capacity of their governing bodies (being prepared) to enhance their likelihood of: being persistent (resisting disturbances), being adaptive (absorbing disturbances without crossing a threshold into an undesirable and possibly irreversible trajectory), and seeking positive transformation (innovating towards desirable trajectories). We elaborate on each dimension below and apply these to examples from the ARCH project estuaries and lagoons (Table 1).

Persistence

The idea of persistence remains essential to resilience, even when we have rejected a simple ‘engineering’ account of the concept. To give an example of this, after a forest fire, even when passing through the full adaptive cycle, with its ‘creative destruction’ phase, some features will persist; there is still a forest floor, which may be rich in seeds (some conifers require high heat for seeds to germinate), and can regenerate a new forest without human intervention. The composition of the new forest may, however, vary greatly from the former one and be of a lesser human and natural value. To take another example, even a devastating coastal flood that takes swathes of farmland out of production will nevertheless leave much of the land intact, although now perhaps more suitable for the more limited range of species that can tolerate salinity. The resilience framework, however, adds to persistence the overlapping component of human preparedness, which permits a degree of choice over what features of a system will be made robust to withstand future socio-economic and environmental changes. In making such a choice, the deliberations in the participatory workshops of the ARCH project have shown that the main tension is often between economic and environmental values.

While some lagoons are threatened with losing areas of coastline through sea level rise (such as Amvrakikos gulf in Greece), others confront the opposite situation whereby conditions have been artificially engineered to keep the sea out for various reasons, ranging from flood risk prevention (as in NordRhine Delta connected with Rotterdam), to making freshwater conditions more favourable for breeding economically advantageous fish species An example of the latter is the Razelm-Sinoe lagoon in Romania. Here, historical interventions took place to engineer saltwater out of the lagoon in order to breed economically valuable fish species and generate a fresh water source for agricultural irrigation. Today, faced with sea level rise such interventions may require reinforcement to ensure the persistence of this economically vital resource for the region. However, the enforcement of freshwater conditions in the lagoon has already resulted in some loss of biodiversity, while a degree of saltwater intrusion might again raise the complexity of the lagoon ecosystems.

Engineering-based adaptation strategies may be appropriate for the gradual sea level rise that is anticipated to occur in the next 50 to 100 years, affecting most coastal communities. However, with regard to extreme climate events that create immediate threats to human life, such as severe storms and inundations, those strategies that place a premium on the persistence of a communications and mobility infrastructure may be equally vital for resilience, for the simple reason that they facilitate human networking and collaboration. The latter are at the heart of ecological and socio-ecological approaches to resilience – as we now go on to discuss.

Adaptability

Adaptability has two main dimensions – flexibility and resourcefulness. Flexibility implies the possibility of choosing alternatives, taking different or new routes and approaches in order to adapt to new circumstances. Resourcefulness entails the efficient, effective and flexible use of resources – including human resources and social capital.

The essence of flexibility is the existence of networks that facilitate flows of ideas and resources, or enable connections between people and institutions (Janssen *et al*. 2006). For example, a growing number of studies show how social networks have helped post-disaster recovery (Nelson *et al*. 2007). Part of adaptation in relation to climate resilience therefore, will concern strategies to connect up institutions and individuals and encourage flexibility in networking, problem-solving, self-organising and applying plans and strategies to emerging situations. The following two examples from Bergen in Norway and the Broads in the east of England will illustrate these points.

In Bergen Byfjorden, the local community became involved in the management of contaminated sediments during a research project on ‘Sediment and Society’. A stakeholder group was recruited based on their areas of influence and interest with regard to contaminated sediments. These represented users of Byfjorden, residents’ associations, environmental NGOs, research institutes, business and representatives of the various administrative authorities. After the completion of the research project, the stakeholder group continued to provide input to a sediment remediation pilot test proposal. Although the focus of the stakeholders' work was primarily on sediment, the group nevertheless continued to participate in other activities related to the management of the Byfjorden in light of climate change effects (Oen *et al*. 2010).

The Broads is another example of an approach where strong involvement of local stakeholders through the formal mechanism of a management Board has joined up institutions and provided a flexible network for management of the local lagoon system. Under the 2008 Climate Change Act, the United Kingdom government directed organisations with functions of a public nature to prepare reports on how they are assessing and acting on the risks and opportunities from a changing climate. Other bodies were invited to voluntarily produce a similar report. The English National Parks, of which the Broads is a member, accepted this invitation. Towards this end, the Broads Authority (BA) formed a Broads Climate Change Adaptation Panel which includes representation from Natural England, the Environment Agency, local authorities, the National Farmers Union, the University of East Anglia, and the BA itself. The panel is linked with the Broads Forum – a representative forum bringing together 30 different interests in the Broads – to keep the process open, seek advice and check assumptions. Furthermore, the BA conducted its own climate risk assessment in spring 2013, which involved the wider community and produced a research report which was to be fed into its Climate Change Adaptation Strategy. The practical reason behind the strong public engagement strategy in the Broads may be due to the fact that 77% of the land under the BA is privately owned (Broads Authority, undated). Cooperation from many and diverse kinds of landholders is essential for the implementation of any effective strategy. The thinking behind the overall climate change adaptation planning was to generate an inclusive process, using a 'preliminary draft' as a starting point that would "provide the foundation for dialogue with wider interests to provide deeper understanding and build commitment" (ibid.). We return to the way the BA's adaptation planning was developed between 2013 and 2015 in a later section. The point here is to highlight the role played by the existence of flexible networks in achieving adaptability.

Part of resourcefulness is strategies for finding replacements for resources that have suddenly become unavailable. For example, after Hurricane Katrina a dramatic loss of city revenue meant serious staff shortage at a time when more were needed, to work on recovery. So, instead of paid staff, students on placement were brought in and contributed fresh perspectives and energy to the problems (Reardon *et al.* 2009). Resourcefulness can be further subdivided into efficiency, rapidity and diversity. These highlight the potential costs and timescales of dealing with uncertainties and the necessity of timely interventions, combined with the cultivation of heterogeneity in a system, so that the temporary or permanent inactivation of one element does not bring the whole system crashing down. Efficiency demands that measures to counter one type of change are compatible with other challenges. The overlap of preparedness with efficiency means ensuring that major investments in one action do not run counter to other efforts. For example, in the Rhine Estuary the operations of the seaport and the carbon-intensive engineering works for climate adaptation have major carbon emissions implications (Meyer *et al*. 2012). This shows how efficiency can be reduced by a lack of effective planning and synergistic policy for climate change adaptation and mitigation.

Another example is the Amvrakikos Gulf which also represents a lack of synergy between economic and environmental policy goals – resulting in a loss of efficiency and thus ultimately, of adaptability. As with many other coastal wetlands in Europe, substantial areas of the Gulf were drained for agriculture, freshwater was diverted from the wetlands and the two rivers embanked. The resulting disruption to the natural hydrology of the wetland complex had negative impacts on both local wildlife and the new farming initiatives. In a very short space of time, salinification put the land out of productive use. Several other factors also contributed to the wetlands' deterioration, including logging, poisoning of birds for predator control, overgrazing, illegal hunting and pollution from nearby factories (Europa, undated).

With regard to diversity, adaptability might encompass, for example, diverse sources of employment rather than over-dependence on just one industry such as agriculture or fishing. In practice this entails understanding 'redundancy' (duplication or overlap of function) as a positive rather than a negative attribute. Seen positively, there is a resilience value in functions that replicate each other and remain separate, rather than being concentrated in a single location or 'bundle', because this reduces the likelihood of a breakdown in one location causing system-wide impacts. For example, having a single major transport hub serving an entire region could be seen as curtailing resilience, particularly where that hub is vulnerable to extreme events such as flooding. Likewise, the principle of bundling together a range of infrastructure in the same location would seem to set major limits on resilience. Thus, when a road is rendered inaccessible or inoperable, in many cases this will have implications for telecommunications, water supply and energy supply, as all are using the same corridor.

At the cusp of heterogeneity and efficiency is the Rhine estuary economy, which has traditionally been highly dependent on the location of the Rotterdam main port, the biggest port in Europe. A quarter of the city of Rotterdam is 'blue space' and some other areas are around six meters below sea level making the city particularly vulnerable to flooding, while the wealthier area, north of the Nieuwe Maas river, is on peatland and subject to shrinking to lower levels under the pressure of summer heat and drought. The considerable engineering and hydrological challenges represented by the delta location, between the estuaries of the Rhine and Maas rivers, is the historical and actual source of the area's specialisation in hydraulic engineering, accounting for 17% of the total Netherlands' production (RCI 2013). This specialism has contributed to the city's decision to market itself globally to other delta-located cities as a leader in climate adaptation innovation, which at present accounts for 3,600 jobs in the region (ibid., 7). Indeed, "the creation of new jobs for the people of Rotterdam in the 'green-blue' economy and delta technology sectors are increasingly becoming the driving force behind economic growth and provide job opportunities for both the highly educated and the unskilled alike" (ibid. 29). This can be interpreted as an example of efficiently using the challenge of adapting to a changing climate to meet the parallel challenge of the economic downturn and its impacts on employment and prosperity in the city.

The converse of this good example is seen in the port of Hamburg on the Elbe estuary. Here the exclusive concentration on benefits to the port has generated a host of negative consequences for other aspects of the region. In particular, environment-related ecosystem services were to a large degree sacrificed due to deepening of the Elbe to accommodate today's supersized container ships, as well as building up the sides with defensive dykes to protect the port from storm surges. These have led to the increasing 'channelizing' of the Elbe, and reducing access to the adjacent flood plains, which between the twelfth century and current epoch, have been reduced by 98% of their extent (Eichweber 2007). Besides the loss of ecosystem services, consequences of this channelization include: increased concentrations of suspended matter in the tidal system, increased sedimentation in the remaining mud flats, a higher current velocity of the river and elevated storm surge water heights. With the tidal current moving the water several tens of kilometres twice a day, the sandbanks in the estuary area are subject to permanent change. This leads to erosion and sedimentation that requires massive investments to mitigate.

Transformability

Where a system has passed through the adaptive cycle and reorients to a new and positive trajectory, it can be said to have transformability. To return to the simple case of the forest fire mentioned above, a naturally regenerated forest is likely to be inferior to its predecessor, perhaps being restricted only to those flora and fauna that can tolerate a high carbon content to the soil, with a more homogeneous age range of trees and a prevalence of robust invasive species that crowd out their more delicate competitors. The example given in *Panarchy* of the Mesa Verde national park in New Mexico saw the easy regeneration of the oak and serviceberry shrublands while the evergreen part of the forest was likely to be colonised by grasses and non-native plants such as thistle – it was anticipated that the evergreen part of the forest might take around 300 years to regenerate (Holling and Gunderson 2002). In such a case, after the fire, a forestry body or local community might intervene to artificially improve soil quality, increase natural variety and remove the invasive species and, as a consequence, the regenerated forest might actually be a better place for natural and human life than its predecessor. This will be all the more likely to succeed if techniques for effective forest regeneration have been innovated and piloted elsewhere, and the results disseminated widely so that there is likely to be an understanding of how to achieve a better outcome and people skilled and experienced in doing this. Preparedness for positive transformability implies both innovation and availability of knowledge and skill around that innovation. An attempt to instil transformability is illustrated by the methods used in the ARCH workshops in Lesina, a lagoon in the Apulia region on Italy's east coast by the Adriatic Sea (more or less across the sea from the Croatian port of Dubrovnik). Lesina has the typical lagoon problems of eutrophication and siltation. Fishing in the lagoon is a recreation for locals and a supplementary job for sea fishermen and farmers. Although there is a bird conservation area, outside of the National Park, wildfowl shooting is permitted. The lagoon has also recently developed watersports as part of its tourism offer. It can be said that as the fish yield of the lagoon is not central to many people's income, there has been insufficient pressure to support measures to halt the declines in its productivity.

A further aspect of the management problem is the sheer number of fragmented plans and strategies (no less than seven) that apply to overlapping parts of the Lesina lagoon and its region. There is no unified plan for the lagoon as a whole and no coordination between the existing plans. Highlighting this lack of coordination, the ARCH workshop in Lesina, mentioned above, attempted to develop the stakeholders' collective imagining of their region by introducing six future scenarios for what the lagoon might look like in 2040, each vividly communicated through the medium of science-fiction fantasy style cartoon strips. The scenarios looked at actions to manage the lagoon that might be taken, or not taken, in the near future, and extrapolated their consequences to a quarter of a century's time, in interaction with wider developments in the national and international context of employment, migration and the economy. Some of the scenarios envisaged a depleted and undesirable future, some portrayed a better-managed lagoon, but most scenarios were designed to take into account the trade-offs involved in any future between, for example, high employment and a neglect or abandonment of wildlife conservation. In prompting people to think beyond their own sector and immediate concerns and consider how a depleted future for the next generation might be avoided and how a more sustainable future might be brought about, the exercise was a first step in embedding the potential for transformability into the system dynamics of Lesina lagoon.

Another example of transformability is Amvrakikos lagoon where fishing restrictions have been put in place to avoid irreversible depletion of stocks. This has met with understandably hostile reactions from a proportion of those fishermen who were entirely dependent for their livelihood on fishing this lagoon. Others, however, have considered the restriction as a positive move on the basis that it will not only help sustain the fish stock for future generations and maintain species biodiversity, but also help generate new opportunities and economic diversification of the region through the stimulus to find alternative employment. The resulting employment diversification not only benefits the region (for example, where some fishermen have taken second jobs as drivers for the fire department during the fire season of June-August), but also the fishermen themselves by instilling a variety of sustenance and income. Indeed, some fishermen have already taken up livestock farming or beekeeping on their own lands, which makes them more resilient to vicissitudes in the success or market value of any one type of produce.

Transformability, therefore, is about the potential in socio-ecological processes to move towards different and more desirable paths. In this context, human preparedness implies the recognition of such possibilities while acknowledging that achieving them requires political will, imagination and creativity. These can be fostered through preparatory measures that engage society in the problems and potentials of the transformation and acknowledgment that managing lagoons is not just a technical or environmental challenge, “but a social, political and normative challenge”, as highlighted by the Royal Commission on Environmental Pollution (RCEP 2010, 109). In other words, bringing new trajectories and transformations to the table opens up the wider debate about what kind of future is desirable.

Preparedness

The dimension of preparedness unites the above three domains of resilience in socio-ecological systems, fostering the persistence of important infrastructure, flexibility with regard to policies and practices, the efficient use of resources to meet challenges in an integrated way, timely interventions, cultivating diversity and redundancy to minimise system-wide impacts, and steering transitions away from diminished and depleted outcomes towards futures that offer wider benefits. While all strategies and plans can be said to contribute to preparedness, fostering evolutionary resilience demands addressing the inherent uncertainties in lagoon socio-ecological systems. It requires addressing the impacts of gradual shifts as well as of co-occurring events and the implications for the various inter-nested systems in the long and short terms and at various scales. The latter may be the hardest challenge of all, because genuine preparedness requires us to step outside the boundaries and remits of existing governance institutions and communities of interest to critically assess at what spatial scale and on which time scale each potential challenge is best addressed. This requires a high degree of reflexivity and social learning as well as inclusive public debate and participation. It requires drawing on all forms of knowledge and in particular locally embedded knowledge (Davoudi, 2015) which form a crucial part of the system's memory and can reveal conventional wisdoms, past legacies and traditional ways of coping with change.

A problem for preparedness is where there are impermeable barriers between different parts of a system, particularly where organisations responsible for different aspects of management do not communicate or are working to incompatible organisational goals and remits. For example, in the Vistula lagoon in Poland, the goal of economic regeneration appears to be in conflict with conservation measures. For example, protected Landscape Park status prevents development of some of the most deprived rural areas to accommodate ex-urban migration. Furthermore, the lagoon falls under the jurisdiction of two distinct geo-political entities that are split between Poland, a member of the European Union, and the Russian Federation, with the only access from the lagoon to the sea controlled by Russia. Within Poland, the lagoon falls under two different regions which have different socio-economic profiles and sectoral interests; and the various municipalities that border the lagoon have a different level of interest in it, depending upon whether or not they also border the sea. The result is a lagoon area that is perceived to suffer from a lack of coordinated governance and direction, symptoms of which may be the continued flight of younger people and a high unemployment rate.

A good example of preparedness comes from the Broads where, as noted earlier, a very high level of consultation has been invested to engage all ages and sections of the population in developing plans for climate change adaptation. This planning was originally quite narrowly delimited, being focused on the current agricultural, environmental and leisure functions of the Broads and in particular threats from increased flows and falls of water (BA 2011). But mid-way through the process a 'Climate Smart' perspective was adopted from the National Wildlife Federation in the US. Although this approach, unlike the scenario-building that took place in Lesina, pays no attention to the interactions between changes in the Broads area and their role within multiple social, political, economic and environmental transformations, it nevertheless, includes a raft of measures that fit well under the banner of Preparedness, for example:

- Understanding how climate change might affect our goals, objectives and management choices, as they may need to be modified to be realistic
- Focusing on future possibilities rather than trying to retain the past
- Being flexible to cope with the uncertain nature of climate projections
- Addressing climate impacts and uncertainties alongside other pressures
- Considering what to do locally within the context of the broader landscape
- Reducing greenhouse gas emissions
- Avoiding adaptation that actually makes (other) things worse
- Improving evidence and understanding. (BA 2015, 7).

Moreover, through participatory working with its stakeholders and publics, the Broads Authority produced a draft Broads Adaptation Plan at the heart of which was public engagement, with the format, length and style of language all designed to be accessible to as wide a public as possible (BA 2015). Although the transparency and participatory nature of the Broads process has slowed down the adaptation plan's final delivery against target, it has developed preparedness not only in terms of awareness of risks and their related preventative and responsive actions, but also in terms of building consensus for action across an area whose conservation and agricultural produce are of major national importance but where ownership is split among a large number of private landowners, NGOs, businesses and public bodies.

CONCLUSION

Lagoons and estuaries which lie at the interface of land and sea are dynamic and complex socio-ecological systems. They are sources of not only major natural capitals and critical ecosystem services, but also inspiration, cultural heritage and recreational values, all of which contribute to the wellbeing and sustainability of humans and nature.

In this paper, we applied an evolutionary resilience framework with four dimensions: persistence, adaptability, transformability and preparedness, to these complex systems using illustrative examples that relate to estuaries and lagoons studied in the ARCH Project. We demonstrated that resilience is not just about persistence and returning to the status quo or what is perceived as 'normal'. It is also about adapting to change and more importantly being prepared to create opportunities for progressive transformation. It is about breaking away from an undesirable 'normal' and mobilising opportunities for new trajectories. This agenda involves not only technical and scientific knowledge, but also requires social and political will and mobilisation. The latter depends largely on the extent and quality of public engagement in lagoon management practices. While resilience is centrally about preparedness, it is important to note that too much preparedness can lead to wastage of resources and more importantly stifling of creativity and spontaneous responses to unpredicted events. A key challenge of governing dynamic and complex socio-ecological systems such as lagoons is how to maintain a balance between pre-defined, planned actions and allowing sufficient room for innovative, self-organised and disruptive actions. As yet, no easy formula has been found but the answer lies in the opening up of the decision spaces to the wider stakeholders and mobilising their agency. This is because instilling more complex systems thinking as entailed in considering the many interwoven aspects of resilience is often furthered through a process of social learning. Such learning can be enabled through the relationship building and participatory process of stakeholder engagement – but requires more than just participation and locally-specific social and institutional relationships. That is, the social learning that fosters preparedness can originate in, but must extend outside of and beyond, the engagement process. An element of this might be identified in the Bergen example, where an initial and very topic-specific consultation was able to be developed and expanded through subsequent wider engagement processes. In light of this, it would be interesting in the future to explore the social and institutional legacies of the stakeholder engagement that took place in the processes enabled by the ARCH project.

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Figures

Figure 1 Four-dimensional framework for building evolutionary resilience